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# Improving the Efficiency of a High Pressure Turbine by Using Non-Axisymmetric Endwall: A Comparison of Two Optimization Algorithms

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**Abstract :** Axial flow turbines are commonly designed with high loads that generate strong secondary flows and result in high secondary losses. These losses contribute to almost 30% to 50% of the total losses. Non-axisymmetric endwall profiling is one of the passive control technique to reduce the secondary flow loss. In this paper, the non-axisymmetric endwall profile construction and optimization for the stator endwalls are presented to improve the efficiency of a high pressure turbine. The commercial code NUMECA Fine/ Design3D coupled with Fine/Turbo was used for the numerical investigation, design of experiments and the optimization. All the flow simulations were conducted by using steady RANS and Spalart-Allmaras as a turbulence model. The non-axisymmetric endwalls of stator hub and shroud were created by using the perturbation law based on Bezier Curves. Each cut having multiple control points was supposed to be created along the virtual streamlines in the blade channel. For the design of experiments, each sample was arbitrarily generated based on values automatically chosen for the control points defined during parameterization. The Optimization was achieved by using two algorithms i.e. the stochastic algorithm and gradient-based algorithm. For the stochastic algorithm, a genetic algorithm based on the artificial neural network was used as an optimization method in order to achieve the global optimum. The evaluation of the successive design iterations was performed using artificial neural network prior to the flow solver. For the second case, the conjugate gradient algorithm with a three dimensional CFD flow solver was used to systematically vary a free-form parameterization of the endwall. This method is efficient and less time to consume as it requires derivative information of the objective function. The objective function was to maximize the isentropic efficiency of the turbine by keeping the mass flow rate as constant. The performance was quantified by using a multi-objective function. Other than these two classifications of the optimization methods, there were four optimizations cases i.e. the hub only, the shroud only, and the combination of hub and shroud. For the fourth case, the shroud endwall was optimized by using the optimized hub endwall geometry. The hub optimization resulted in an increase in the efficiency due to more homogenous inlet conditions for the rotor. The adverse pressure gradient was reduced but the total pressure loss in the vicinity of the hub was increased. The shroud optimization resulted in an increase in efficiency, total pressure loss and entropy were reduced. The combination of hub and shroud did not show overwhelming results which were achieved for the individual cases of the hub and the shroud. This may be caused by fact that there were too many control variables. The fourth case of optimization showed the best result because optimized hub was used as an initial geometry to optimize the shroud. The efficiency was increased more than the individual cases of optimization with a mass flow rate equal to the baseline design of the turbine. The results of artificial neural network and conjugate gradient method were compared.

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